Inversion of multiwavelength Raman lidar data for retrieval of bimodal aerosol size distribution

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We report on the feasibility of deriving microphysical parameters of bimodal particle size distributions from Mie–Raman lidar based on a triple Nd:YAG laser. Such an instrument provides backscatter coefficients at 355, 532, and 1064 nm and extinction coefficients at 355 and 532 nm. The inversion method employed is Tikhonov's inversion with regularization. Special attention has been paid to extend the particle size range for which this inversion scheme works to ~10 μm, which makes this algorithm applicable to large particles, e.g., investigations concerning the hygroscopic growth of aerosols. Simulations showed that surface area, volume concentration, and effective radius are derived to an accuracy of ~50% for a variety of bimodal particle size distributions. For particle size distributions with an effective radius of <1 μm the real part of the complex refractive index was retrieved to an accuracy of ±0.05, the imaginary part was retrieved to 50% uncertainty. Simulations dealing with a mode-dependent complex refractive index showed that an average complex refractive index is derived that lies between the values for the two individual modes. Thus it becomes possible to investigate external mixtures of particle size distributions, which, for example, might be present along continental rims along which anthropogenic pollution mixes with marine aerosols. Measurement cases obtained from the Institute for Tropospheric Research six-wavelength aerosol lidar observations during the Indian Ocean Experiment were used to test the capabilities of the algorithm for experimental data sets. A benchmark test was attempted for the case representing anthropogenic aerosols between a broken cloud deck. A strong contribution of particle volume in the coarse mode of the particle size distribution was found. © 2004 Optical Society of America

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1. Introduction

Aerosols are one of the key atmospheric constituents that influence the Earth's radiation budget and require a detailed characterization of optical and physical properties to reduce uncertainties in the modeling of the planet's radiative forcing.[1] Because of the highly variable lifetime of tropospheric aerosols of the order of days to weeks,[2] their inhomogeneous spatial distribution over the globe, as well as different source and transport paths, continuous monitoring is demanded. Satellite-based aerosol remote sensing provides for global coverage. Ground-based aerosol remote sensing is best suited for reliable and continuous monitoring of aerosol properties in key locations. Aerosol sounding with multiwavelength lidar in recent years has emerged as a powerful tool that is capable of providing comprehensive, quantitative information of aerosol properties on a vertically resolved scale.[3,4]

Techniques for the retrieval of microphysical particle parameters from multiwavelength lidar, developed since the early 1980s,[5–7] have made major progress in the past 5 years.[8–12] In that respect the most successful technique has been developed at the Institute for Tropospheric Research (ITR), Leipzig, Germany. It was developed initially for the retrieval of aerosol size distribution parameters and complex refractive indices from a multiwavelength Mie–Raman lidar that provides backscatter coefficients at six wavelengths and extinction coefficients at two wavelengths.[13] In recent years this tech-

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